

How can Artificial Intelligence tools help mitigate the phenomenon of Overtourism?

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Abstract

Overtourism is becoming increasingly significant and the use of novel technologies in the tourism sector is also gaining prominence, particularly to manage its challenges. This study proposes a conceptual overview, using the framework proposed by MacInnis (2011), to understand how Artificial Intelligence (AI) tools can help mitigate the phenomenon of overtourism. Based on the identification of key AI applications in the tourism sector, the research examines the issues related to overtourism and the strategies currently adopted to address them, ultimately hypothesising which AI tools are effective in tackling these issues. The results highlight the potential of using AI tools in stemming the phenomenon. Among the most effective applications that would seem to encourage the redistribution of tourist flows are customised recommendation systems and tools that guide tourists to less popular destinations, reducing pressure on overcrowded areas. In addition, dynamic pricing techniques and tourism demand forecasting enable more sustainable management of visitor flows, while the use of robots and facial recognition technologies helps mitigate the social and environmental impacts of mass tourism, improving safety and reducing the impact on residents and stakeholders.

Keywords Overtourism; Artificial Intelligence (AI) in Tourism; Sustainable Tourism Management; Visitor Flow Redistribution

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Introduction

In recent years, the travel and tourism market has faced significant challenges due to the rise of overtourism, a phenomenon characterized by excessive tourist traffic that leads to social, cultural, environmental, and economic issues in popular destinations. This increase in tourism has been driven by factors such as evolving consumer preferences, changing market trends, rising disposable incomes, the ease of travel, and a growing desire for unique experiences (Statista, 2023). In particular, the travel and tourism market is expected to witness a significant increase in revenue, reaching a value equal to 916 billion USD by 2024 and growing at a 3.99% annual rate, resulting in a market volume of 1,114 billion USD by 2029 (Statista, 2023). More recently, mass tourism or so-called overtourism has risen drastically, becoming the root cause of social, cultural, environmental and ecological issues (Dodds and Butler, 2019; Gonzalez et al., 2018) and resulting in anti-tourism protests occurring in popular locations (Dodds and Butler, 2019).

Mass tourism, in particular, presents significant challenges for both destinations and their local communities. These challenges include environmental degradation, which can disrupt wildlife habitats, cause pollution, and increase waste (Nakayama, 2023). Additionally, the high volume of tourists can create cultural issues, such as the loss of a location's authenticity and a diminished visitor experience due to congestion, long queues, and reduced service quality (Rickly, 2019). Moreover, overtourism can lead to social issues, including disruptions to the daily lives of residents, escalating tensions between locals and tourists (Milano et al., 2019; Renkert et al., 2019), rising costs of living that make housing, goods, and services less affordable for residents, and deteriorating infrastructure that requires frequent repairs to roads and public transportation (Renkert et al., 2019).

More recently, artificial intelligence (AI) has been revolutionizing the tourism industry, thereby enhancing customer service (García-Madurga and Grilló-Méndez, 2023; Doborjeh et al. 2022), customer experiences (Chiwariidzo and Chiwaridzo, 2024; Gómez and Frías, 2022; Doborjeh et al. 2022) and operational efficiency (Doğan & Niyet, 2024; Jewandah et al., 2024; García-Madurga and Grilló-Méndez, 2023; Chen et al., 2023). Through the use of algorithms and innovative methods for analysis and forecasting (Doborjeh et al. 2022; Duvnjak et al., 2020; Song et al. 2019; Liu et al. 2019) can automate and optimize processes (Dogan et al., 2024), personalise user experiences (Jewandah et al., 2024; García-Madurga and Grilló-Méndez, 2023), as well as increase customer satisfaction (Elkhwesky et al. 2022; Li et al. 2021a) and customer loyalty (Jewandah et al., 2024).

In particular, AI in the tourism industry facilitates tasks such as room bookings, reservations, check-ins and check-outs, responding to customer inquiries, and managing hotel services (Citak et al., 2021). Additionally, AI-based recommender systems help tourists find options that best match their interests (Gao et al., 2010), while content customization and personalized pricing enhance customer targeting (Kumar et al., 2019). AI also includes the use of mobile apps, kiosks, in-person customer services, chatbots, and messaging tools, providing almost instantaneous 24/7 responses on social media platforms, enhancing customer experience, and offering personalized and

efficient services, such as ordering food and cabs, scheduling tasks, and providing information about hotel facilities (Gajdošík and Marciš, 2019).

Previous research has been carried out to understand the potential of digital technologies in tackling the challenges of overtourism, particularly focusing on the metaverse, extended realities, virtual reality, augmented reality, and mixed reality as tools to help ease this phenomenon (Kouroupi and Metaxas, 2023). So far, however, there has been little discussion of the impact of artificial intelligence (AI) tools in mitigating the phenomenon of overtourism. With this in mind, the present study aims to define the main applications of AI in the tourism sector, the issues generated by overtourism, and the existing strategies adopted to address this phenomenon, and the potential of AI tools to help alleviate overtourism.

Methodology

The study proposes a conceptual framework suitable for understanding how Artificial Intelligence (AI) tools can help mitigate the phenomenon of overtourism. It builds upon the framework proposed by MacInnis (2011) for developing conceptual contributions in marketing and management studies. MacInnis (2011) outlines four broad types of conceptual contributions: envisioning new ideas, relating ideas, explicating ideas, and debating ideas, each with two subtypes of contributions. For this study, we adopted MacInnis' 'Explicating' framework (specifically the Delineating and Summarizing subtypes), as it provides a structured and systematic approach suitable for addressing the three proposed research sub-questions. Table 1 presents the main issues addressed in this paper.

With this approach, the study aims to provide a comprehensive understanding of how AI can be leveraged in the tourism sector to enhance existing practices and address the pressing issue of overtourism.

<i>Research Questions</i>	<i>Phase</i>	<i>Objective</i>	<i>Methods</i>	<i>Output</i>
<i>RQ1: What are the main applications of AI in the tourism sector?</i>	Delineating	Identify and select the main AI tools used in the tourism industry.	Literature review using scientific databases (WoS, Scopus) and industry sources to collect relevant studies, articles, and reports.	Summary table of AI applications.
	Summarizing	Categorize and summarize AI tools by type.	Create a table summarizing existing applications.	
<i>RQ2: What are the main problems caused by overtourism in tourist destinations and the current strategies adopted to mitigate them?</i>	Delineating	Identify the problems caused by overtourism and the mitigation strategies.	Comprehensive research in major scientific databases (Web of Science, Scopus) and industry sources, including academic studies and documents from governmental and non-governmental organizations.	Summary table of problems and mitigation strategies.
	Summarizing	Categorize problems and strategies by type.	Create a table for a clear view of the issues and strategies.	
<i>RQ3: Which AI tools can effectively combat the phenomenon of overtourism?</i>	Delineating	Identify AI tools that are effective in managing tourist flows.	Review of previously identified AI technologies and assessment of their potential impact on addressing the identified issues.	A model showing the potential integration of AI tools to manage tourist flows and mitigate overtourism.
	Summarizing	Illustrate how AI tools can be integrated to optimize tourism flows and resolve overtourism-related challenges.	Create a table illustrating the integration of AI tools to address issues related to overtourism.	

Table 1 Research methodology (source: authors' own elaboration)

Results

RQ1: The role of AI in tourism sector

Artificial intelligence (AI) is revolutionizing various sectors, including hospitality and tourism by enhancing customer service (García-Madurga and Grilló-Méndez, 2023; Doborjeh et al. 2022), customer experiences (Chiwariidzo and Chiwaridzo, 2024; Gómez and Frías, 2022; Doborjeh et al. 2022) and operational efficiency (Doğan & Niyet, 2024; Jewandah et al., 2024; García-Madurga and Grilló-Méndez, 2023; Chen et al., 2023). AI utilizes algorithms and innovative methods of analysis and forecasting to automate and optimize processes (Doborjeh et al. 2022; Duvnjak et al., 2020; Song et al. 2019; Liu et al. 2019, Dogan et al., 2024). This enables novel opportunities, such as the assessment of large datasets and the personalization of user experiences (Jewandah et al., 2024; García-Madurga and Grilló-Méndez, 2023), which, in turn, increases customer satisfaction and loyalty (Jewandah et al., 2024).

Artificial intelligence in tourism and hospitality offers increased customer experience (Chiwariidzo and Chiwaridzo, 2024; Gómez and Frías, 2022) through the provision of customized recommendations and optimized service delivery to meet consumer preferences and needs (Jewandah et al., 2024; García-Madurga and Grilló-Méndez, 2023). Similarly, AI and machine learning contribute to enhancing travel experiences by anticipating user needs, making recommendations, and automating processes, learning tourist behaviour, providing recommendations, and integrating tourist applications into automation (Tsaih and Hsu, 2018). In addition, AI solutions can communicate in a human-like language, enabling tasks like room bookings, reservations, check-outs, customer inquiries, and hotel services (Citak et al., 2021). In addition, recommender systems assist tourists in finding options that best suit their interests, thereby tailoring information based on preferences, moving from mass to individual marketing (Gao et al., 2010). By analysing consumer habits, social media activities, online behaviour, and past transactions (Campbell et al., 2020), along with algorithms and social sentiment analysis (Fan et al., 2020), AI facilitates website content customization and personalized prices, thus enhancing customer targeting (Kumar et al., 2019). Yang et al. (2024) discover that consumers' perceptions of personalized tourist recommendations is determined by perceived personalization, visual appearance, and information quality. While exploring the relationship between robotics, AI, and service automation adoption their impact on social, economic, and environmental sustainability, Chiwaridzo & Chiwaridzo (2024) uncover that through the strategic incorporation of such technologies, tourism businesses and policymakers can improve the tourism experience, ensure the long-term profitability of the industry, and improve its positive impact on society, the economy, and the environment. AI and machine learning can also enable tourists to share their experiences, supporting other tourists' decision-making and enhancing their self-image on social networks (Tsaih and Hsu, 2018).

AI is also transforming hospitality through mobile apps, kiosks, and chatbots, contributing to enhanced customer experience and operational automation. Main uses of AI in the tourism industry include in-person customer services, chatbots and messaging tools, business intelligence tools powered by machine learning, as well as

virtual reality and augmented reality (Citak et al., 2020). Chatbots play a significant role in the tourism and hospitality sector by providing almost instantaneous responses 24/7 to customers on social media platforms, enhancing customer experience at hotels, providing personalized and efficient services, and offering a wide range of services such as ordering food and cabs, scheduling tasks, and delivering information about hotel facilities (Gajdošík and Marciš, 2019). Additionally, they store data to provide personalized recommendations (Samala et al., 2020).

Voice assistants play a significant role in easing interactions between hotels and guests, while also fulfilling a pivotal role in assisting hotels to enhance customer service, expand operational capabilities, and reduce costs (Buhalis & Moldavska, 2022). Robotic and chatbots can assist with travel information, while natural language processes can provide instant translation and image recognition (Tsaih and Hsu, 2018). Facial recognition allows for the identification and verification of tourists' faces through their documents, allowing them to pass through airports and stations without requiring document verification from authorities (Samala et al., 2020; Chang and Yang, 2008). In addition, Google Translate provides audio-voice features that enable users to speak in their native language, translate into the local language, and dictate their input to locals (Azis et al., 2011). This is especially beneficial for illiterate travelers and even works offline (Samala et al., 2020). The latest camera function further supports users in the translation of menus and signs into their favoured language through the mobile camera (Tatwany and Ouertani, 2017), improving interactions and experience with locals and in unknown locations (Bayern, 2018). Google Maps and other similar AI-powered applications, provide live views of the real world by scanning landmarks such as buildings and storefronts, allowing tourists to identify their location and explore local businesses and attractions while navigating safely, thus enhancing location-based experiences (Xiao et al., 2018) and delivering valuable information. With respect to the hospitality industry, one of the broader instruments of AI, ChatGPT, is explored in the context of customer service by investigating the experiences and perceptions of employees (Limna & Kraiwanit, 2023). The findings reveal that its incorporation enhances employee skills and knowledge, overcomes language barriers, provides precious recommendations, and stimulates productivity (Limna & Kraiwanit, 2023). Moreover, in the tourism industry, ChatGPT helps integrate customer service into front-of-house operations and boosts productivity and efficiency in back-of-house operations (Carvalho & Ivanov, 2024). It also enhances concierge services by assisting with bookings, queries, providing feedback, room services, translation, training employees, operational efficiency, marketing hotels, and travel guidance (Abdullah, 2023).

In addition, AI technologies contribute to data analytics through predictive and forecasting analyses (Duvnjak et al., 2020) by allowing personalised offers based on consumer preferences and behaviour (Jewandah et al., 2024). AI is particularly relevant in terms of adoption in various market applications, including demand forecasting, big data analysis, automation and robotics (Santos et al., 2024). Similarly, AI assists in predicting prospective business conditions and revenues, as well as identifying current and potential trends in tourist demand (Doborjeh et al. 2022). In addition, AI-based analytics and predictive modeling maximize revenue management, favouring data centric decisions and dynamic pricing strategies (Jewandah et al., 2024). Service robots

outperform humans in high customer contact settings due to their mechanical and analytical nature (Reis et al., 2020) by assisting with tasks like managing luggage check-ins, welcoming guests, handling room service and guiding tourists, thus enhancing customer experiences, simplifying work processes, and increasing efficiency (Samala et al., 2020).

AI-based technologies also offer fraud detection and security measures (Infante-Moro et al., 2021), ensuring the safety of both customers and businesses while enhancing customer satisfaction (Kumar and Sharma, 2024; Al-Hyari et al., 2023).

Table 2 provides an overview of the main AI tools and their features employed in the tourism and hospitality sector.

Although the application of AI in the tourism and hospitality sector offers numerous advantages, it also poses significant challenges. One of the primary obstacles is the high cost of acquiring and implementing the necessary technology (e.g., robots, kiosks, chatbots, or software development), which can be substantial (Ivanov & Webster, 2019). Despite these initial costs, the long-term implementation of such technologies could lead to significant cost and time savings, reduce human error, and enhance service quality (Jewandah et al., 2024; Ho et al., 2022). However, this transition also poses the risk of job losses, as reliance on technology could diminish the human touch in customer service, leading to overreliance on automation and reduced human interactions (Yasin & Gedecho, 2024; Saini & Bhalla, 2022). Additionally, AI systems rely on large volumes of data, which heightens concerns about privacy and data security. Ensuring the protection of customer data is therefore crucial to maintaining trust and compliance with regulatory standards (Ivanov & Umbrello, 2021).

<i>AI tools</i>	<i>Description and authors</i>
Robots	Service robots outperform humans in high customer contact settings due to their mechanical and analytical nature. AI-enabled robot technologies, by incorporating empathetic intelligence, may replace human intelligence. Therefore, firms should evaluate whether service robots are capable of completely replacing human labor or invest in balanced options like human-robot systems, which seem more rational today (Reis et al., 2020)
	Robots are driven by IoT technology to assist with tasks like turning on lights, managing luggage check-ins, and welcoming guests (Samala et al., 2020). Robot receptionists are becoming popular, handling room service to ensure a smooth stay for guests and enhancing customer experiences in hotels (Samala et al., 2020). In airports, they serve as guides and assistants, improving customer experience, simplifying work processes, and increasing efficiency (Samala et al., 2020).
	Service robots in the hospitality industry operate through voice commands and AI technology to assist guests with controlling room amenities (Ivanov and Webster, 2019).
	Virtual agents and chatbots provide customer service by offering helpful suggestions for attractions and restaurants, improving overall performance (Michaud, 2018).
Chatbots and messaging	Chatbots provide 24/7, almost instantaneous responses to customers on social media platforms. This is crucial for hotels, as human-to-human interaction is difficult to maintain (Radhakrishna and Gupta, 2020).
	AI natural language processing and pattern recognition capabilities are being utilized to enhance tourism services, including chatbots and voice customer assistants, providing real-time 24/7 services (Tsaih and Hsu, 2018).
	Chatbots enhancing guest experience at hotels, providing personalized and efficient services, offering a wide range of services such as ordering food and cabs, scheduling tasks, and providing information about hotel facilities (Gajdos'ık and Marcis', 2019) and, also storing guest data to provide personalized recommendations (Samala et al., 2020).
	By messaging with AI chatbots, users can also obtain trip plans (Lalicic & Weismayer, 2021).
Facial recognition	Facial Recognition is an AI function used in the travel and tourism industry to identify tourists' faces, verify them with documents, and facilitate hassle-free check-ins (Samala et al., 2020).
	It allows tourists to pass through airports and stations without requiring document verifications from authorities like immigration and customs (Chang and Yang, 2008).
Google maps	By using AI, Google Maps offers live views of the real world, scanning for landmarks like buildings and storefronts, enabling tourists to pinpoint their location and explore local businesses and attractions, navigating confidently, enhancing location-based experiences (Xiao et al., 2018), while providing valuable information about their surroundings.
Language translation	Google Translate offers audio speech services through its "Conversation mode" option, allowing users to speak in their language and then translating into the local language and dictated to the local people (Azis et al., 2011), assisting especially illiterate travelers and working also offline (Samala et al., 2020).
	The more recent camera integration feature supports users in translating menus and signboards into their preferred language through the phone camera (Tatwany and Ouertani, 2017), thereby enhancing interactions and experience with locals and in unfamiliar places (Bayern, 2018).
Pricing	AI and the Maximum Likelihood algorithm enable service providers to optimize services by analysing past data to suggest price likelihood values (Moraga-González and Wildenbeest, 2008), thereby predicting price rise or drops (Song and Jiang, 2019) and enabling customers to make informed decisions on when to book services like hotels, flights, and cabs (Samala et al., 2020)
Forecasting tourism demand	To forecast tourist arrivals to different destinations using monthly time series data (Akm, 2015) and understanding the determinants of re-visiting (Shapova et al., 2017)

Personalisation and recommender systems	AI uses location and preferences to intervene in real-time via clients' cell phones. It offers personalized travel options through social media based on lifestyles and preferences (Pei & Zhang, 2021).
	Recommender systems assist tourists in finding options that best suit their interests, tailoring information based on preferences and facilitating moving many to one marketing (Gao et al., 2010).
	AI technologies analyse consumer habits, social media activities, online behaviour, and past transactions (Campbell et al., 2020) in order to increase conversion rates (Jablonska & Polkowski, 2017) through algorithms and social sentiment analysis (Fan et al., 2020), customizing website content, offering suitable prices, thus enhancing customer targeting and retention (Kumar et al., 2019).

Table 2 Artificial intelligence (AI) tools (source: authors' own elaboration)

RQ2 Overtourism and overtourism mitigation strategies

As we know, overtourism is characterized by an excessive number of tourists in specific locations, leading to a range of negative consequences. These include environmental issues such as congestion and pollution (Nakayama, 2023), as well as social and cultural impacts like loss of privacy, reduced security, cultural identity erosion, increased prices and infrastructure deterioration (Nakayama, 2023; Bouchon and Rauscher, 2019; Renkert et al., 2019). As a result, the social and environmental costs of tourism often outweigh the economic benefits, highlighting the need for targeted policies to control tourist numbers (Koens et al., 2018; Benner, 2019). Overtourism, driven by factors such as low-cost flights, social media promotion, lifestyle changes, and a desire for self-fulfillment (Seraphin et al., 2019), results in an unsustainable concentration of visitors in areas unable to accommodate them (Vegnuti, 2020), negatively affecting local communities and their quality of life (Dodds and Butler, 2020; Milano et al., 2019). Previous research shows that while social media has become a key tool for tourism marketing, it also contributes to overtourism (Song and Wondirad, 2023). However, it also promotes eco-friendly behaviors, supports tourism displacement, educates visitors, and improves destination management (Murphy et al., 2018). Effective management of overtourism requires clear communication, setting standards, and providing services to ensure a smooth visitor experience, as well as monitoring visitor numbers and environmental impact for timely interventions (Song and Wondirad, 2023). Studies by Koens and Postma (2017) identified strategies such as dispersing tourists, time-based rerouting, regulation, visitor segmentation, enhancing city infrastructure, and involving local stakeholders. Meanwhile, Medway et al. (2010) discuss demarketing strategies like sustainability, segmentation, seasonality reduction, and crisis management. These strategies help destinations manage visitor numbers, ensure long-term sustainability, attract specific visitor segments, and prevent overtourism-related problems.

Table 3 below summarises the main problems caused by overtourism and the current mitigation strategies adopted.

<i>Problem</i>	<i>Strategy</i>	<i>Description</i>
Visitors focusing only on popular destinations	Brand positioning	Brand positioning can promote lesser-known destinations, while repositioning can highlight other strategic attributes of a destination. Demarketing may be necessary to conserve uniqueness and carrying capacity strategies can help divert tourists from overcrowded parks to less-known destinations (Taecharungroj et al., 2024).
Social, cultural, environmental and ecological issues	Social media - education	Destination management organisations (DMOs) can foster sustainable behaviour or brands in offering green tourism packages and demonstrating eco-friendly consumption patterns on social media, while encouraging tourists to share their experiences (Nakayama, 2023). Social media promote responsible tourism behaviours by supporting identity construction, gamification, and using social media influencer power to create awareness about travelling responsibly (Song and Wondirad, 2023).
Excessive tourist flow	Entry regulation	Limited supply (hotels) and access (landing rights, car park etc.) can be implemented through check points and gates to limit the number of visitors (Peltier, 2018). However, limiting accommodation facilities, making areas harder to access, or limit parking has proven ineffective, as seen in the case of Mallorca (Blázquez-Salom et al., 2019).
Affordable travel destinations as well as increased cost of living (for locals)	Pricing control and increases	Tax on arrivals, paying sites, tax on operators, secondary homes, etc., along with price increases (Avond et al., 2019), prove to be effective in mitigating overtourism (Gülser et al., 2021). Increasing entrance fees has shown to reduce the number of visitors (Kainthola et al., 2021).
Tourist concentration in “hot spots”	Diversification and dispersion	By utilising social media, it is possible to diversify tourist attractions as well as to disperse tourists (Song and Wondirad, 2023). Social media can also divert tourists from hot spots through a recommendation system. Furthermore, content generated and disseminated by visitors enables DMOs to develop an advanced alert system using big data (Song and Wondirad, 2023). Diversification or market segmentation can help avoid overtourism phenomena and address carrying capacity issues (Camatti et al., 2020)
Disruption of resident-city relations	Resident benefits	Residential incentives (Koens and Postma, 2017) and providing access to only locals to some areas (Lam, 2018)
	Creating enjoyable city experiences for both tourist and locals	Koens and Postma (2017)
	Visitor and stakeholder (residents) involvement	Koens and Postma (2017)
Environmental deterioration	Infrastructure and facilities improvement	Koens and Postma (2017)
Unethical behaviour	Severe regulations	Levying fines for tourists for not following stipulated rules in certain areas (Coffey, 2018)

Table 3 Overtourism problems and mitigation strategies (source: authors' own elaboration)

RQ3: AI as a support to solve overtourism issues

The analysis conducted shows how the adoption of artificial intelligence (AI) tools in the tourism sector can offer innovative and effective solutions to address the problems associated with overtourism (Table 4).

<i>Issue</i>	<i>AI tool</i>	<i>Solution</i>
Visitors focusing only on popular destinations	Personalisation and Recommender Systems	Recommendation systems can suggest lesser-known but equally interesting alternative destinations based on the personal interests of the tourist. This can help to better distribute tourist flows, reducing pressure on the most popular places.
	Google Maps	Promoting alternative itineraries and attractions to better distribute tourist flows.
Social, cultural, environmental, and ecological issues	Forecasting Tourism Demand	Forecasting tourist demand can help identify periods of high influx and prepare accordingly, reducing negative impacts on society and the environment. This forecast can inform policies to limit visitors or implement sustainable practices.
	Robots	In areas with ecological problems, robots can be used to monitor and maintain the environment.
Excessive tourist flow	Pricing	Dynamic pricing can modulate demand by raising prices during peak periods or in overcrowded areas while offering lower rates for less frequented destinations. This approach can help reallocate tourist flows more equitably.
	Facial Recognition	This technology can be used to better manage visitor flows, limiting access to certain areas when a certain capacity is reached, and improving security and operational efficiency in crowded places.
Affordable travel destinations and increased cost of living (for locals)	Forecasting Tourism Demand	Forecasting tourism demand can help local authorities better plan for economic development and implement policies that balance tourism with the daily lives of residents, preventing living costs from excessively due to tourism pressure.
	Chatbots and Messaging	Provide real-time information on fares and convenient travel options to reduce pressure on cheap destinations.
Tourist concentration in "hot spots"	Personalisation and Recommender Systems	Suggest less crowded alternatives based on tourists' preferences and the situation of "hot spots".
	Google Maps	Guiding tourists to less congested areas with real-time data.
Disruption of resident-city relations	Facial Recognition	Improving security and preventing unlawful acts to maintain good relations between residents and tourists.

	Language Translation	Improving communication between tourists and residents can reduce cultural conflicts.
Environmental deterioration	Robots	Robots can be used for environmental maintenance tasks, such as waste collection and wildlife monitoring, thereby reducing the negative impact of tourism on the environment.
	Forecasting Tourism Demand	Avoiding overcrowding in ecologically sensitive areas through sustainable management of tourist flows.
Unethical behaviour	Facial Recognition	Identifying and preventing unethical or illegal behaviour by tourists.
	Chatbots and Messaging	Educating tourists on ethical behaviour and local regulations through reminders and useful information.

Table 4 Integration of AI tools to mitigate overtourism (source: authors' own elaboration)

Discussion

The findings of this study underscore the potential of artificial intelligence (AI) tools in addressing the multifaceted challenges posed by overtourism. By integrating advanced technologies such as personalized recommendation systems, tourism demand forecasting, and the use of robots and facial recognition, the tourism industry can effectively mitigate the negative impacts of mass tourism on destinations, local communities, and the environment. The following are the hypothesised applications of AI.

Redistribution of Tourist Flows

One of the most promising applications of AI identified in this study is its ability to redistribute tourist flows through personalized recommendation systems and tools like Google Maps. These technologies can guide tourists towards lesser-known but equally attractive destinations, thereby alleviating pressure on overcrowded areas and contributing to a more equitable distribution of tourism's economic benefits. This aligns with previous research by Gao et al. (2010) and Campbell et al. (2020), who highlighted the effectiveness of AI in tailoring experiences to individual preferences, thereby dispersing visitor concentration.

Tourism Flow Management

The application of dynamic pricing techniques and tourism demand forecasting emerges as another critical strategy. These tools allow for the modulation of visitor flows, preventing overcrowding and ensuring a more sustainable use of local resources. As shown in studies by Seraphin and Ivanov (2020) and Song et al. (2019), AI-driven dynamic pricing can effectively manage demand by adjusting prices based on real-time data, thereby discouraging excessive concentrations of tourists during peak periods.

Social and Environmental Impact Mitigation

AI technologies offer innovative solutions for mitigating the social and environmental impacts of overtourism. The use of robots for maintenance and environmental monitoring can reduce the direct impact of visitors on sensitive ecosystems, as suggested by Reis et al. (2020). Similarly, facial recognition technology can enhance safety and prevent unethical behaviour, contributing to a more harmonious relationship between tourists and local residents, as supported by findings from Samala et al. (2020) and Chang and Yang (2008).

Enhancing Communication and Cultural Understanding

Chatbots and language translation tools play a pivotal role in improving communication between tourists and locals, reducing cultural conflicts and fostering greater mutual understanding. This is crucial for maintaining positive perceptions of tourism among local communities, as indicated by Buhalis & Moldavska (2022) and Tsaih and Hsu (2018).

However, while AI adoption in the tourism industry offers numerous advantages, it also presents challenges that cannot be overlooked. The high implementation costs of AI

technologies and the potential reduction of human interactions in customer service are significant concerns. As noted by Ivanov & Webster (2019) and Yasin & Gedecho (2024), balancing the benefits of automation with the need to maintain a human touch in tourism services will be critical to the sustainable integration of AI in this sector.

Conclusion

This research highlights the potential role of AI in mitigating overtourism through the proposal of a theoretical model. The integration of advanced technologies such as personalized recommendation systems, tourism demand forecasting, and the use of robots and facial recognition technologies can help reduce the negative impacts of mass tourism on destinations, local communities, and the environment, while promoting a more balanced and sustainable distribution of tourist flows. Among the proposed solutions, the diversification of tourist destinations stands out as particularly effective. Recommender systems and interactive maps are powerful tools for redistributing tourist flows, encouraging visitors to explore lesser-known yet equally fascinating destinations. Additionally, AI-driven management of tourist flows, using dynamic pricing techniques and demand forecasting, can regulate visitor influx, preventing overcrowding and ensuring a more efficient use of local resources. Technologies such as facial recognition and robots offer significant potential for sustainable tourism management, reducing environmental impact and improving relations between tourists and residents.

The conceptual approach proposed in this research, which suggests AI tools to address overtourism issues, can benefit managers and practitioners in the tourism sector. Implementing such AI tools can offer significant competitive advantages, enabling more efficient management of tourist flows and personalization of offerings that enhance customer experience while mitigating the negative impacts of mass tourism. Destination managers should consider integrating recommendation systems and dynamic pricing techniques to promote a more balanced temporal and geographical distribution of visitors. Despite its innovative approach, this research presents certain limitations. The proposed conceptual model is based on a review of existing literature and the authors' theoretical assumptions; thus, empirical analysis is necessary to confirm its practical applicability. Future research should investigate the effectiveness of AI tools in various tourism contexts. Furthermore, exploring the interaction between AI and other tourism management tools, such as augmented and virtual reality, could provide insights into how combined technologies can contribute to more sustainable tourism.

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